ARS 42-69
August 1962

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

MULTIPATH DRYING AT COTTON GINS FOR CONTROLLING MOISTURE IN COTTON

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In 1931 the U.S. Cotton Ginning Research Laboratory at Stoneville, Miss., successfully demonstrated the practicability of a seed cotton drier for use at cotton gins.[2/] Because dry cotton results in better preparation and can be cleaned much more readily than damp cotton, artificial drying has greatly expanded the use of cleaning machinery at the gin. The practice of drying and cleaning cotton at the gin has developed gradually through the years to meet the demands arising from rougher harvesting methods. To handle damp cottons, most gins are now equipped with two driers. Controlling the driers to give optimum drying and to prevent overdrying, which lowers cotton quality, has imposed a serious problem at gins.

BACKGROUND OF CONTROLLED DRIER DEVELOPMENT

In the early 1930's the wide variations in moisture content of cotton arriving at gins was recognized. Moisture surveys including a special moisture and drier survey of representative gins in the Miss. Delta were made.[3/]

The fact was readily established that the moisture content throughout any mass of seed cotton, in its natural state, is not uniform. Also there is no established proportion or ratio of moisture between lint and seed.

During the early years of the Stoneville Laboratory, work was done on developing rapid moisture-testing devices,[4/] and studies were made on hysteresis and hydroscopicity of cotton. Investigations of the physical structure and cell structure of the cotton fiber were also made. USDA fiber technologists

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2/ Bennett, C. A., The Vertical Drier for Seed Cotton, U.S. Department of Agriculture Misc. Pub. 149, 1932.

3/ Shaw, C. S. Report of Mississippi Delta Moisture Survey Covering Years 1931 through 1935. Office report, U.S. Cotton Ginning Research Laboratory.

4/ Gaus, G. E.; Shaw, C. S.; and Kliever, W. H., A Practical Seed Cotton Moisture Tester for Use at Gins. U.S. Department of Agriculture Cir. No. 621, 1941. Shaw, C. S., Moisture Measuring Instrument - Patent No. 2,365,496, 1944.

studied the cellulose cell and the complex physical structure of the cotton fiber and found that excessive heating and drying could have adverse effects on fiber quality (Fig. 1.) Within a few years, further advances were made in

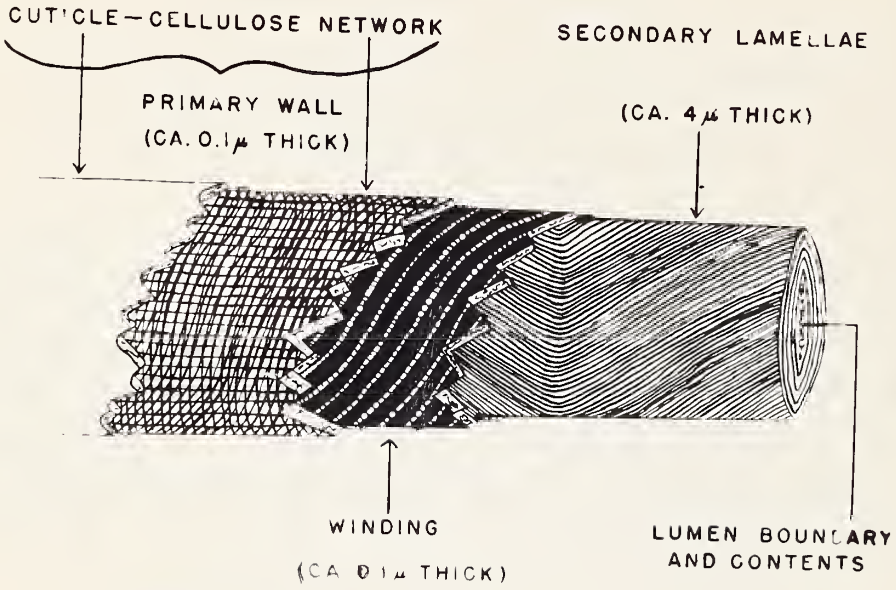

Figure 1. Schematic diagram of cotton fiber, based largely on microscopical observations. Each fiber consists of several layers or walls, and fibrils wound around a central lumen.

cotton-drying systems,[5/] and as early as 1938, personnel at the U.S. Cotton Ginning Research Laboratory became interested in the possibility of automatic control of driers and the synchronization of variations in drying intensity with moisture content of cotton.

In work with existing cotton-drying systems, consideration was given to various methods of control, including control by humidity-measuring devices. Immediately following World War II, when more personnel became available, studies were made on cotton moisture adsorption, absorption, and the time-lag in regain of moisture by artificially dried cotton. Studies were made of the time required to remove surface moisture or "free" water, and of the conse-

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5/ Bennett, C. A., and Gerdes, F. L. The Vertical Drier for Seed Cotton. U.S. Department of Agriculture Mis. Pub. 239. 1936 (revised 1941). Bennett, C. A., and Shaw, C. S. Overhead Cleaner-Drying Systems for Seed Cotton. U.S. Department of Agriculture Misc. Pub. 314. 1938.

quence of removing "bound" water. Tests proved that proper drying has no adverse effect on fiber quality, but that controlled drying is necessary to maintain optimum drying conditions. During the past few years, results of extensive research have indicated that, because of time-lag involved in varying the drying temperatures, the very limited drying exposure time in a gin system would not permit rapid and satisfactory drying control.

PIPE DRYING STUDIES

In 1959 experiments at the Stoneville Laboratory centered around fixed temperature and variable exposure time.

A 300-foot, uninsulated, 16-inch-diameter pipe system was installed, with facilities for pneumatically conveying seed cotton from the wagon and delivering it into a heated stream of air flowing through the pipes at different air volumes and temperatures (Fig. 2). Eighteen sampling stations were provided

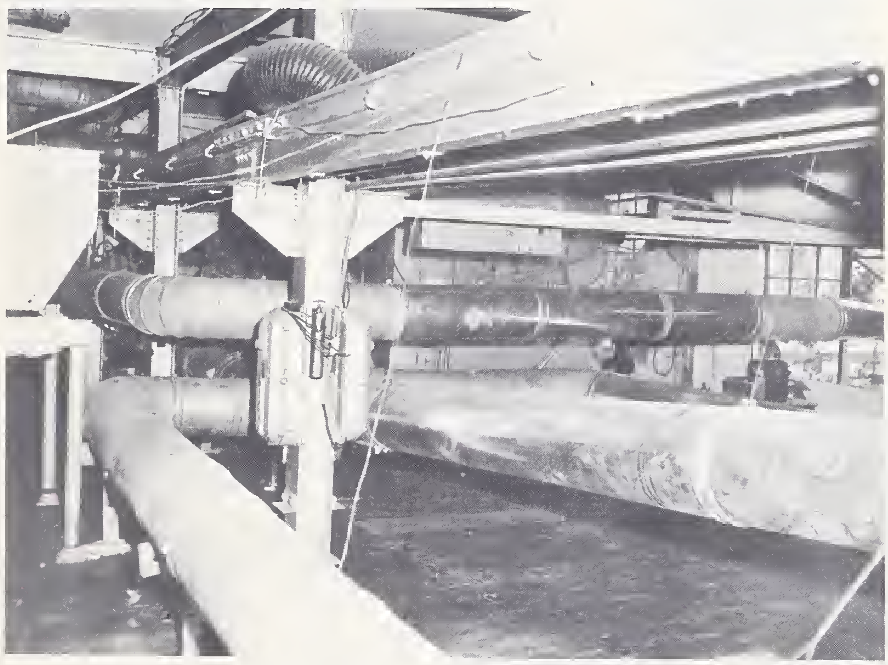

Figure 2. View of a part of the 300 feet of piping used in the moisture-control studies.

along the pipe from which seed cotton samples could be taken and sealed in airtight cans for moisture tests (Fig. 3). A strip-chart temperature recorder was used for recording air temperatures during the experiments (Fig. 4).

Figure 3. Taking a sample during moisture-control experiments. Note gloves and leather sleeve worn for protection from the very hot air and metal pipe.

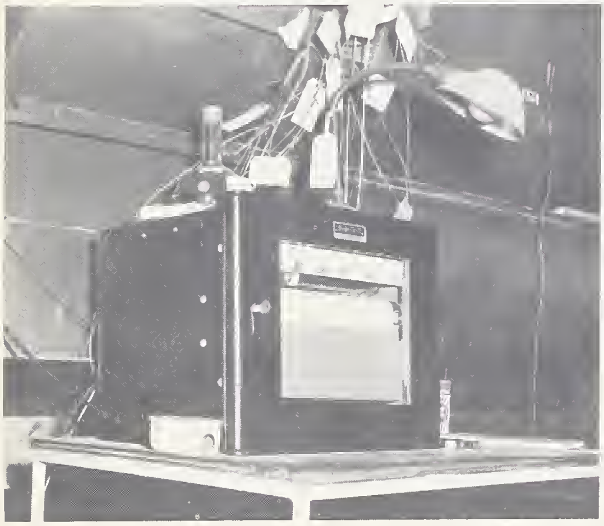

Figure 4. Temperature recording instrument used in the moisture-control studies. The tagged wires lead to the different sampling stations.

Four series of experiments were conducted to establish rate-of-drying data for the design and operation of heated-air-conveying drying systems.

Data revealed moisture evaporation to be very rapid for 2 or 3 seconds, at an initial temperature of 285° F., after which the drying rate was considerably reduced. Drying was accomplished with an air-to-cotton ratio of 47 cubic feet of air per minute per pound of seed cotton. These data indicated that the drying curve breaks sharply when cotton surface moisture has been removed.

THE MULTIPATH DRIER

Pipe-drying studies and other moisture-control research[6/] led to the design and construction of a multipath tower drier capable of path selection (Fig. 5).

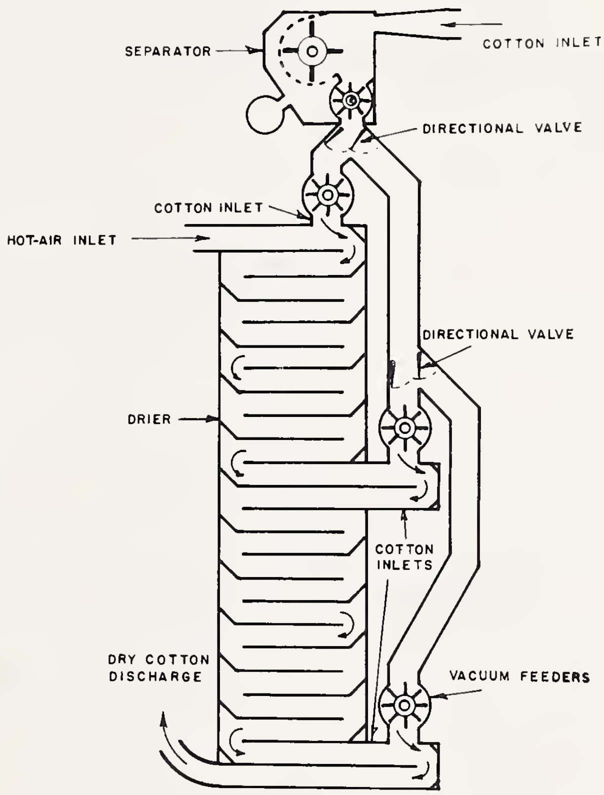

Figure 5. Diagram of the multipath tower drier.

The multipath drying system consists of a conventional, 24-shelf tower drier modified to provide, in addition to the hot-air inlet and a dried-cotton discharge, three cotton inlets sealed by conventional vacuum feeders. This allows cotton to be injected into the hot-air stream without air loss. Hot air flows through the entire drier at all times during operation.

6/ Franks, G. N., and Shaw, C. S. Progress Report Multipath Drier Development. The Cotton Gin and Oil Mill Press. 1961.

By means of a conventional separator mounted on top of the drier, cotton may be fed into the drier at this point; or it may be diverted downward by directional valves not required to be airtight, since cotton passes through the rectangular duct by gravity.

Each set of directional valves is operated by two air cylinders, one at each end. The air cylinders are actuated by compressed air supplied through a solenoid-operated pilot valve, that is mounted midway between the two air cylinders to provide a balanced air pressure through two rubber hoses to each cylinder (Fig. 6). Vacuum feeders provide entry to the drier either midway or near the bottom, as directed by the second set of valves. Sizes and speeds of the separator and vacuum feeders are governed by the individual installation.

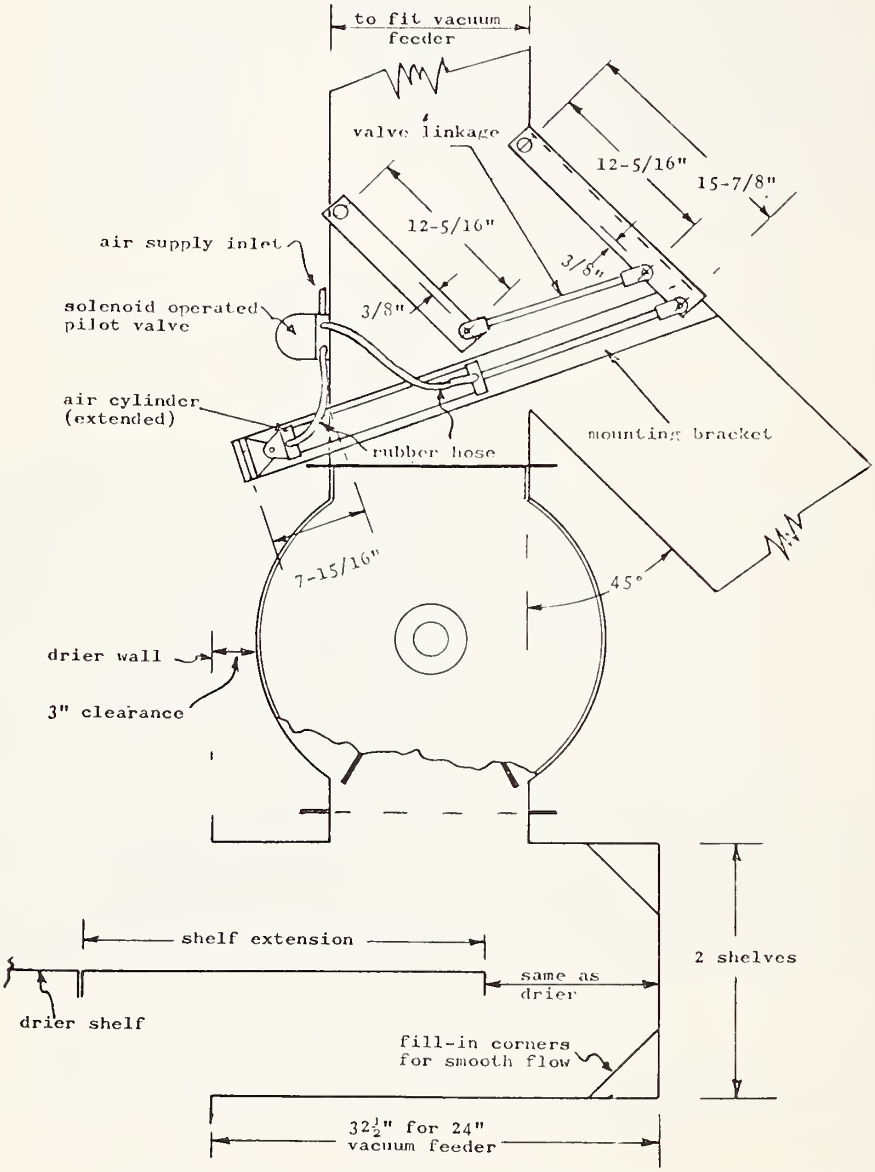

Figure 6. Diagram showing details of multipath drier valve control.

The drier is constructed so that the cotton may be directed three ways--through the full long path (24 shelves); through the middle path (13 shelves); or through the short path (1 shelf).

The path selection may be operated automatically by moisture-sensing instruments (Fig. 7) or manually by a "single-pole-double-throw" (SPDT) switch placed in a convenient location for the ginner (Fig. 8).

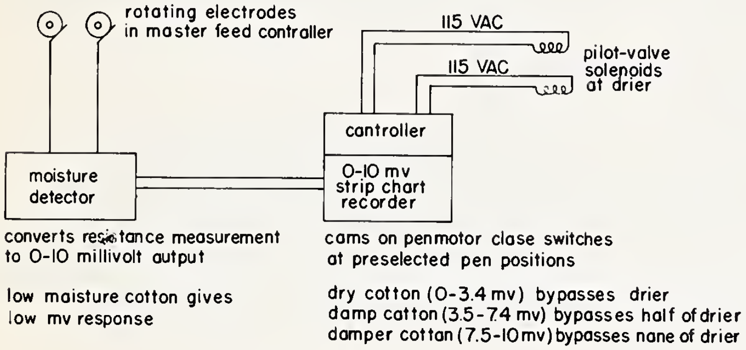

Figure 7. Major elements of the automatic drying control system for the multipath drier.

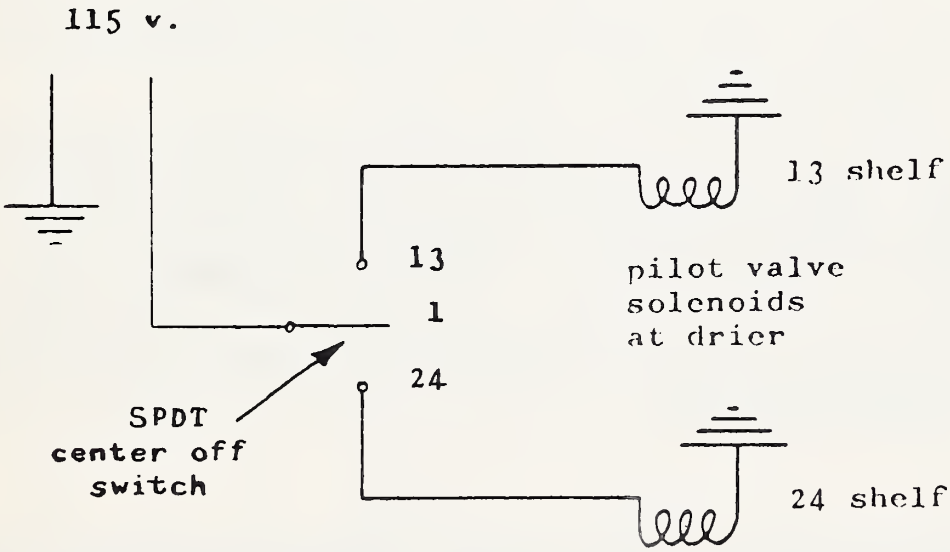

Figure 8. Wiring diagram for the manual operation of the multipath drier system.

For switching the drier path manually, a SPDT center "off" switch should be used. When switch is in "off" position, cotton will pass through only one shelf of the drier. When switched to one of the "on" positions, cotton will pass through 13 shelves of the drier; and when switched to the other "on" position, cotton will pass through the entire drier.

The use of a multipath drier will make possible a flexible drying system capable of responding rapidly to changes in cotton moisture content. It will prove especially useful in public gins that find it difficult to maintain a seed cotton grouping program.

To obtain full use of the drier under manual control, a moisture meter should be used to check the moisture content of the seed cotton entering the system and to spot check lint at the press. If not properly used, this drier, just as any other, can damage cotton.

DRYING EXPERIMENTS

The multipath drier was installed in the 3-stand laboratory gin at Stoneville and was subjected to rather extensive experiments during the fall of 1960. Six early-season, 12 mid-season, and 12 late-season cottons were used in these experiments. The drying system included 80 feet of 14-inch pipe extending from the bottom of the drier to the first cleaner. The total drying exposure time for the three paths was as follows: Long path, 10 seconds; middle path, 6 seconds; and short path, 2 seconds. The air volume used in the drier was 4,760 cubic feet per minute.

For each series of drying tests, samples were obtained at wagon and feed control, before drier, after drier at first cleaner, at feeder apron, and at lint slide.

A push-button control based on the clocked travel time of the cotton through the gin system, was arranged to provide a signal for sampling at each station as the cotton moved through the gin system. Two men were positioned at each station so that samples of seed cotton could be drawn quickly. The use of the three paths was randomized, and samples were drawn in triplicate for each path at successive intervals. Each time a seed cotton sample was drawn, a portion was sealed in an airtight container for an oven-moisture test. Another portion was ginned immediately in an air-conditioned room on a small 6-inch laboratory gin. The resulting seeds and lint were canned for oven and moisture-meter tests.

DRIER TEST RESULTS

Early-Season Cottons. A drier entrance temperature of 350° F., was used in processing the six early-season cottons. The drying results are summarized in table 1.

If the desirable range for lint moisture is considered as 5.0 to 7.0 percent, and the optimum as 6.0 percent, the data in table 1 show that, on an average, the 350° F., temperature accomplished more drying than was needed for these particular cottons, even when using the short path.

Mid-Season Cottons. Six of the mid-season cottons were processed through the multipath drier at a drier entrance temperature of 250° F., and six were processed at 350°. The drying results are summarized in table 2.

Table 1. Moisture removal by multipath drier, early-season cottons, crop of 1960.

Drier temperature ° F.	Moisture content of wagon sample	Lint cotton moisture content: Undried lint ginned from wagon sample 1/	Lint slide samples 2/: Short path	Middle path	Long path
	Percent	Percent	Percent	Percent	Percent
350	12.8	8.8	5.4	4.9	4.5
		Seed cotton moisture content	Feeder apron samples		
350	12.8	---	11.1	11.1	10.7

1/ Ginned on small 6-inch laboratory gin.
2/ Average of 18 samples.

Table 2. Moisture removal by multipath drier, mid-season cottons, crop of 1960.

Drier temperature ° F.	Moisture content of wagon sample	Lint cotton moisture content: Undried lint ginned from wagon sample 1/	Lint slide samples 2/: Short path	Middle path	Long path
	Percent	Percent	Percent	Percent	Percent
250	15.3	10.6	6.9	6.8	6.0
350	14.7	10.5	6.1	5.1	4.7
		Seed cotton moisture content	Feeder apron samples		
250	15.3	---	13.3	12.6	12.3
350	14.7	---	12.9	11.9	11.4

1/ Ginned on small 6-inch laboratory gin.
2/ Average of 18 samples.

The mid-season cottons were damp, and at 250° F., the long path gave optimum drying results, with the lint averaging 6.0 percent in moisture content. The 350° temperature provided an optimum moisture content of 6.1 percent with the short path.

Late-Season Cottons. Six of the late-season cottons were processed through the multipath drier at 250° F., and six at 350°. The drying results are summarized in table 3.

Table 3. Moisture removal by multipath drier, late-season cottons, crop of 1960.

Drier temperature ° F.	Moisture content of wagon sample	Lint cotton moisture content: Undried lint ginned from wagon sample 1/	Lint slide samples 2/: Short path	Middle path	Long path
	Percent	Percent	Percent	Percent	Percent
250	9.9	8.3	5.7	5.3	5.0
350	10.3	8.0	5.1	4.2	3.8
		Seed cotton moisture content	Feeder apron samples		
250	9.9	---	8.7	8.3	7.9
350	10.3	---	8.5	8.2	8.0

1/ Ginned on small 6-inch laboratory gin.
2/ Average of 18 samples.

The wagon-sample moisture content of the late-season seed cottons averaged 9.9 percent for the six dried at 250° F., and 10.3 percent for the six dried at 350°. The moisture content for the corresponding undried lint averaged 8.3 and 8.0 percent respectively. This further confirmed a well-established fact that, in its natural state, no mass of seed cotton is uniform in moisture content, and there is no established proportion or ratio of moisture between the lint and the seed. In these late-season tests, the short drier path at 250°F., came closer to approaching the optimum in drying, with a lint moisture content of 5.7 percent.

SUMMARY OF RESULTS

From a seasonal standpoint, the multipath drying results for the particular range of moisture encountered during the season, with suitable automatic moisture measuring and path selection, showed that the multipath drier would have met variable drying needs (table 4). For the 1960 tests the drier path valves were controlled manually.

Table 4. Moisture removal by the multipath drier, seasonal average, crop of 1960.

Drier temperature ° F.	Moisture content of wagon sample	Lint cotton moisture content			
		Undried lint ginned from wagon sample 1/	Lint slide samples 2/		
			Short path	Middle path	Long path
	Percent	Percent	Percent	Percent	Percent
250	12.6	9.4	6.3	6.0	5.5
350	12.6	9.1	5.5	4.8	4.3
		Seed cotton moisture content			
			Feeder apron samples		
250	12.6	---	11.0	10.5	10.1
350	12.6	---	10.8	10.4	10.0

1/ Ginned on small 6-inch laboratory gin.
2/ Average of 36 samples at 250° F., and 54 samples at 350°.
At 250°, LSD at 1.0 percent = .50 and at 5.0 percent = .35.
At 350°, LSD at 1.0 percent = .26 and at 5.0 percent = .19.

In summarizing, the data confirm the results of the pipe drying studies by showing that the major part of the drying is accomplished early in the drying exposure period. Table 4 shows that for the 250° and the 350° F. drying temperature groups, the undried lint averaged 9.4 and 9.1 percent, respectively; 2 seconds' exposure of the cotton through the short path of the drier reduced the moisture content to 6.3 and 5.5 percent, respectively. An average moisture removal of 0.6 percent was accomplished in the cold-air stream before the cotton entered the drier.

FUTURE DRYING CONTROL PLANS

Past research indicated that, for extreme moisture conditions, a second multipath drier could be included in an automatic drying-path selection system. This is under investigation at the Stoneville Laboratory.

The acceptance and the practical application of multipath drying systems in cotton gins have been dependent upon the development of satisfactory instruments for path selection. An experimental control system for heat-drying cotton at gin plants has now been developed at the U.S. Cotton Ginning Research Laboratory at Stoneville and is being integrated with the multipath drier. An abstract describing this development reads as follows:

"The sensing system uses two rotating electrodes in the master feed control-unit to measure the resistance of incoming seed cotton. This resistance measurement is converted to a 0-10 millivolt signal that is fed into a recorder-controller. Degree of drying is regulated by a micro-switch arrangement that basically controls exposure time in a tower drier. Selection of exposure period is accomplished automatically by the position of the recording pen."[6/]

The cotton moisture problem begins in the fields and follows on through to the textile mills. Moisture has always been a serious problem at the cotton gins; it is a problem now, and it will be a problem in the future. At present, however, automatic drying and moisture control in cotton gins is nearer to reality than ever before.

6/ Griffin, A. C., Jr., and Mangialardi, G. J. Automatic Control of Seed Cotton Drying at Cotton Gins, A Review of Research. U.S. Department of Agriculture, ARS 42-57. 1961.

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